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Rhodora

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MERRITT LYNDON FERNALD, Editor-in-Chief

CHARLES ALFRED WEATHERBY
ALBERT FREDERICK HILL
STUART KIMBALL HARRIS
} Associate Editors

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CONTENTS:

Studies in Chrysosplenium, with special Reference to the Taxonomic Status and Distribution of C. iowense. *C. O. Rosendahl.* 25

Studying Willows or making new Sections in the Genus Salix. *Carleton R. Ball.* 37

Unverified Bibliography of Scirpus. *M. L. Fernald.* 49

Some Noteworthy Catskill Plants. *George R. Proctor.* 53

Use of Formaldehyde in Plant Collecting. *Richard Evans Schultes.* 54

New Station for Epipactis Helleborine in New Hampshire. *Robert J. Titherington.* 60

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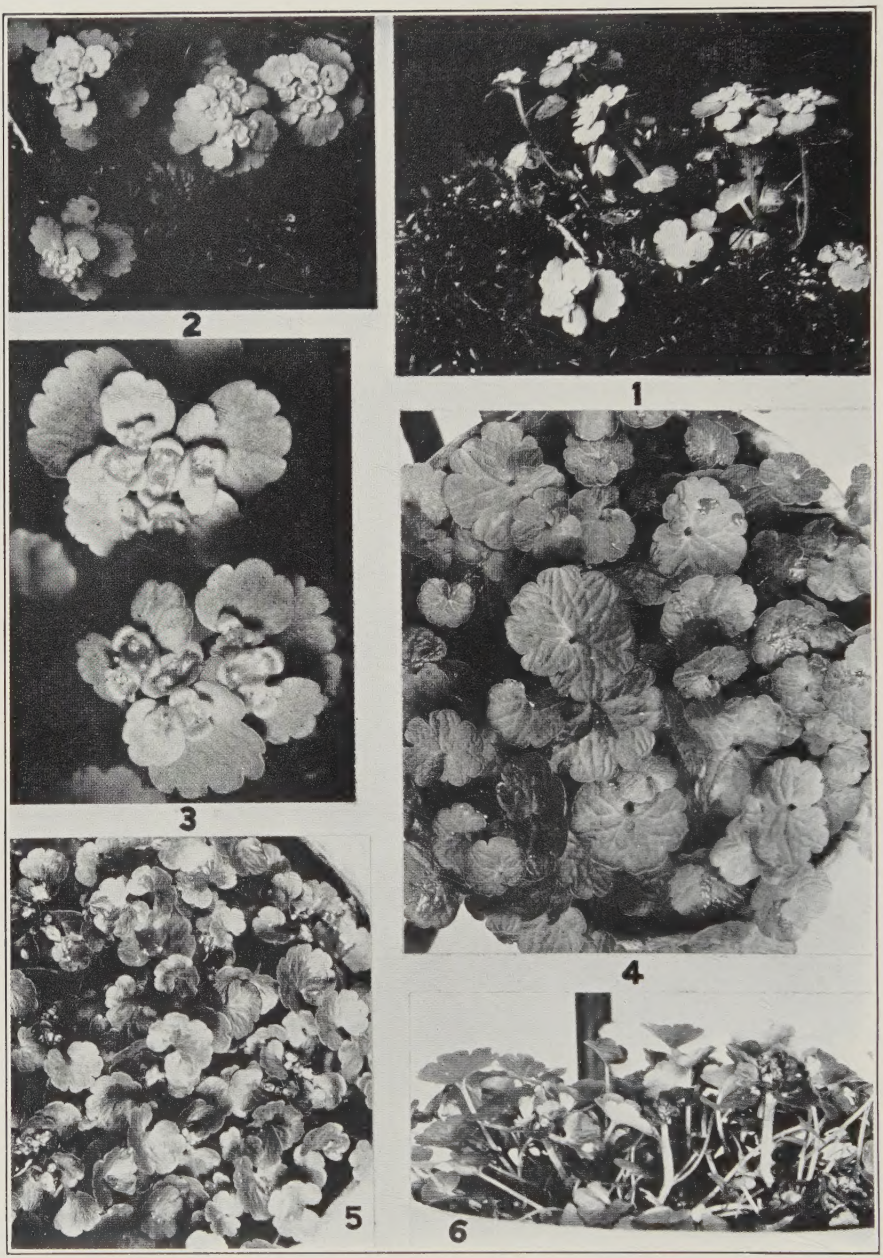

CHRYSOSPLENIUM IOWENSE: FIG. 1, plant, × ⅔, showing stolon-leaves; FIG. 2, plant, × ⅔, from above; FIG. 3, flowering tips, × 1⅓; FIG. 4, plant, × ⅔ showing nearly closed basal sinus and overlapping basal lobes of leaf.

C. TETRANDRUM: FIG. 5, plant, × ⅔, from above; FIG. 6, plant, × ⅔, from side.

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STUDIES IN CHRYSOSPLENIUM, WITH SPECIAL REFERENCE TO THE TAXONOMIC STATUS AND DISTRIBUTION OF C. IOWENSE*

C. O. Rosendahl

(Plates 1053 and 1054)

Several years ago Professor E. H. Moss of the University of Alberta sent me a number of Canadian *Saxifragaceae* for identification. Among them was a specimen of *Chrysosplenium* (*Moss*, No. 280) which I referred to *C. tetrandrum* Fries. I made note of the fact that the number of stamens was not constant, but varied mostly between 8 and 6. This is one of the characters Rydberg[1] used for distinguishing his *C. iowense* from *C. tetrandrum* which, as the name implies, has only 4. I had not been fully convinced that this was a sufficiently reliable character for maintaining the former as a separate species, especially since a number of botanists dealing with *Chrysosplenium* from the Arctic regions of both the New and the Old World have reported finding plants of *C. tetrandrum* in which the stamens varied in number from 4 to 8. Some of them, particularly Simmons[2] and Heintze[3], have emphasized this feature in support of their arguments that *C. tetrandrum* is only an Arctic variety of *C. alternifolium* L. They contend that such plants constitute a "continuous series" bridging the gap between the two.

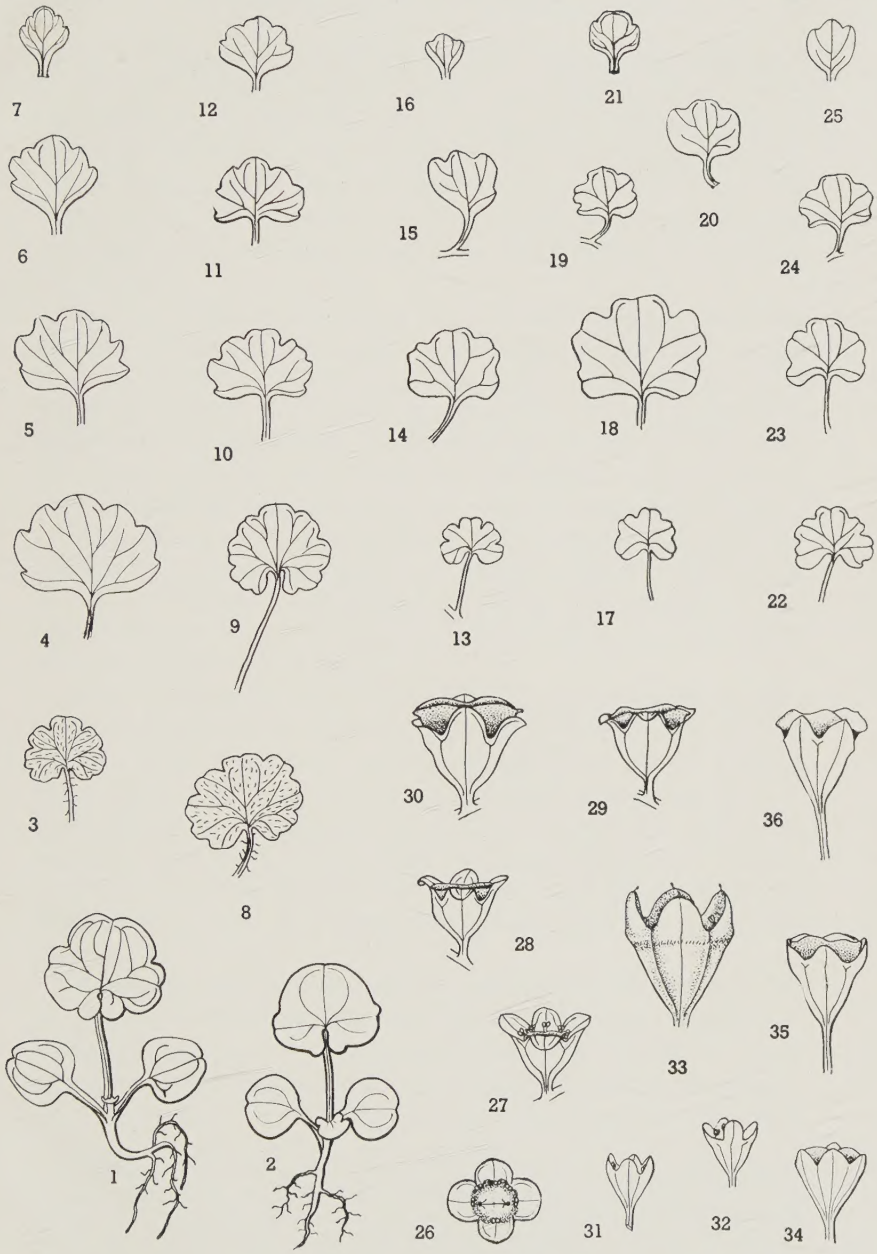
* Contributions from the Herbarium of the University of Minnesota, III.

[1] Britton's Manual, p. 483. 1901.

[2] Simmons, H. G. The Vascular Plants in the Flora of Ellesmereland. Rep. of the Second Norw. Arctic Exped. in the "Fram" 1898–1902. No. 2, p. 59. 1906.

[3] Heintze, Aug. Om *Chrysosplenium alternifolium* L. v. *tetrandrum* Lund och des usbredning inom Skandinavien. Bot. Notiser, p. 231. 1907.

On re-examining the Alberta specimen more thoroughly and comparing it with collections from the type locality in Iowa, I found that it matched the latter not only in the stamen character but in several additional details of flower and fruit structure as well as vegetatively. Although it appeared almost certain that the plant in question could not be anything else than Rydberg's species, yet this meant such a great gap in distribution that I hesitated to commit myself on the basis of only a single specimen. Accordingly I wrote to Professor Moss and asked if perchance he had additional specimens I might see. He kindly responded by sending me five sheets, representing four additional stations, all from within a radius of about 100 miles of Edmonton. All the collections proved to be the same entity and beyond any doubt they belonged with *C. iowense*. However, I was to find out from one of these sheets that the discovery had already been made but apparently left in limbo. The particular sheet is from the herbarium of C. H. Turner and contains two of his collections (No. 471 and 1670) from Fort Saskatchewan, Alberta. It is extensively annotated and the notes are sufficiently illuminating to warrant reproducing in full. The label in the lower right hand corner bears the legend: "Golden Saxifrage, Water Carpet. *Chrysosplenium tetrandrum* Th. Fries. Collector C. H. Turner, No. 471. Wet grounds, Sandhills Ft. Saskatchewan, Alberta June 7, 1935". A line is drawn through the species name and right below it is printed in ink *iowense* Rydb. This name is also crossed out and above both the scratched names is written for a second time *tetrandrum* Fries. There is no signature to show who made these alterations nor is it clear if they were made by one and the same person. It appears likely however, that they are to be attributed to Dr. W. P. Fraser because above the label there is attached a typewritten note by him which reads as follows: "*Chrysosplenium iowense* Rydb. *C. tetrandrum* Fries. Following Rydberg's Key some of our collections fall into this species but from a limited study of the few collections I have made I have grave doubt if it is a good species. It is one of Rydberg's species and as far as I know has not been revised or commented on by any other botanist. It is for you to decide which to use. I'll give more attention to collections but we do not have much of it on the prairies. It is more common in the



Details of Chrysosplenium iowense and C. tetrandrum: figs. 1, 3–12 and 26–30 C. iowense, figs. 2, 13–25 and 31–36 C. tetrandrum.

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north." The note is dated April, 1940. Above this note there is attached another strip of paper on which is typed "1670 *Chrysosplenium tetrandrum* Fries", underneath which is written, Dr. Hugh M. Raup, Mar. 10, 1941. There are altogether eight plants on the sheet, four of which are numbered 471 and the others 1670. They are all the same entity and I assume that Dr. Raup's identification is meant to apply to both of Turner's collections.

One can readily understand Dr. Fraser's dilemma when one recalls how difficult it often is to get a clear concept of a species from keys and descriptions alone, especially when these are much abridged as they so often are in manuals. Without authentic material at hand the job is sometimes quite baffling and obviously Dr. Fraser had no Iowa plants for comparison. As mentioned above I likewise had been skeptical about the full specific status of *C. iowense* and some forty years ago expressed this doubt by placing it in a lower category, not however under *C. tetrandrum* but as a form of *C. alternifolium*.[4] While this disposition was admittedly erroneous, it expressed nevertheless more nearly its true phylogenetic position.

After a prolonged study of a great deal of material[5] of both *C. iowense* and *C. tetrandrum*, including living plants of both entities, I no longer have any doubt about the former being a distinct species. It differs from *C. tetrandrum* and also from *C. alternifolium* in a number of dependable co-ordinating characters some of which have been entirely neglected, and others the importance of which appears not to have been fully recognized. Before taking these up in detail a brief history of the species is in place.

Chrysosplenium iowense was first collected by Professor E. W. D. Holway in 1888 near Decorah, Iowa. The first published account of it appeared two years later in the sixth edition of Gray's Manual where it was referred to the Old World species *Chrysosplenium alternifolium* L. Its distribution in America was there given

[4] Engler's Bot. Jahrb. 37: Beibl. 83, p. 86. 1905.

[5] In addition to the Canadian material of *C. iowense*, I have had access to practically all known collections of it from Iowa including the type. I have also seen all the sheets of *C. tetrandrum* preserved in the Gray Herbarium, the New York Botanical Garden and the herbarium of the University of Minnesota. I wish to express my appreciation to Dr. Moss, Dr. Fernald, Dr. Gleason and Dr. Hayden for the loan of material.

as "Decorah, Iowa, west to the Rocky Mts. and north through Brit. Am." Seven years later Dr. J. N. Rose[6] published a preliminary revision of the North American species of *Chrysosplenium* wherein he maintained that *C. alternifolium* L. does not occur in America and that American material referred to it belonged instead to *C. tetrandrum* Fries. He furthermore stated that after the study of much material he was forced to restore the latter to specific rank despite the fact that recent monographers had considered it only a variety of *C. alternifolium*. The range of the species was given briefly as "Arctic regions, in America as far south as Colorado". He elaborated upon this short formal statement by adding that in the United States there are only two stations recorded for the species. One of these is in Colorado, where the plant had been collected in 1862 by Hall and Harbour (No. 576) and has not been found since, and the other at Decorah, Iowa, where Prof. E. W. D. Holway had collected it a number of times. He suggested that the plant from the latter place might prove a distinct form since it differed in being somewhat larger, with slightly different leaves and with six or seven stamens. Four years later Dr. Rydberg l. c. segregated the Iowa plant as a distinct species, giving it the name *C. iowensis* and pointed out that it had been "confused with *C. alternifolium* L. with dull punctate leaves with truncate lobes and *C. tetrandrum* Fries with thick 3–5-lobed leaves and 4 stamens". In his treatment of the *Saxifragaceae* in the North American Flora (Vol. **22:** Part 2, 83. 1905) Dr. Rydberg corrected the gender of the epithet to *iowense*. The same year appeared my paper on the North American *Saxifragaceae* l. c. where I committed the before-mentioned blunder of treating it as a *form* of *C. alternifolium*. Finally in the seventh edition of Gray's Manual it is referred without any qualifying comments to *C. tetrandrum* Fries and therefore presumably held to be conspecific with the latter.

It is understandable that the independent status of *C. iowense* should have been questioned at the time considering how exceedingly little material was available and how little was actually known about it. Dr. Rydberg had only the two plants of the original collection before him when he drew up his description and these either did not reveal or else he failed to recognize as of

[6] Bot. Gaz. **23:** 274–276. 1897.

diagnostic importance a number of additional stable characters which distinguish it from *C. tetrandrum*. The situation was not improved by his treatment in the North American Flora l. c. for there, except for the two characters he used in the key, i. e. difference in the number of stamens and lobes of the leaves, the descriptions read so much alike that one would be justified in questioning whether the two were really distinct entities. There is however no lack of differentiating characters and it seems strange that such obvious differences in flowers and leaves as are clearly shown in the accompanying photographs (Plate 1053) were not made use of. As early as the seedling stage differences between the species are manifest (Plate 1054, figs. 1, 2). By the time the plants have attained the flowering stage the contrast between them is so marked that mere outward appearance suffices to set them apart as well defined species (Plate 1053, figs. 1–6). In my experiments with growing the plants I find that *C. tetrandrum* produces flowers and matures seed in one season (3–4 months). During the period of active growth several leafy stolons are produced in the axils of the radical leaves. *C. iowense* on the other hand does not develop flowering stems the first season but produces instead a number of radical leaves and stolons. If the latter continue to grow at or close below the surface of the ground they bear a variable number of ordinary green leaves, but when they penetrate deeper their leaves are reduced to the sheathing colorless portion of the petiole and a rudimentary lamina. That the plant behaves the same in nature is indicated by the fact that in all herbarium specimens where I could make out the connection each flowering stem was found to arise from the end of a stolon of the previous season. The radical and stolon-leaves are orbicular-reniform, 7–11-lobed, with a narrow or closed basal sinus due to the overlapping of the basal lobes (Plate 1053, fig. 4; Plate 1054, figs. 3, 8). The blades are rather thin and impressed-veined above and either glabrous or sparingly pubescent on the upper surface; the stolon-leaves are pubescent (Plate 1053, figs. 1, 4; Plate 1054, figs. 3, 8) with erect white hairs on both surfaces, those on the lower side are shorter and less numerous; the lowermost cauline leaf is round-reniform to reniform (Plate 1054, fig. 9), 7–9-lobed and glabrous; the succeeding cauline leaves are flabellate, 6–7-lobed and glabrous

(Plate 1054, figs. 4, 5, 6, 10, 11), the two uppermost are adnate by their petioles to the branches of the dichasial cyme and stand immediately underneath the inflorescence (Plate 1053, figs. 1, 2, 3). The bracts are mostly broadly obovate, 3–5-lobed (Plate 1054, fig. 7), rarely 6-lobed, and lemon-yellow in color at anthesis.

In *C. tetrandrum* the radical and stolon-leaves are reniform, 5–7-lobed, with a rather open basal sinus (Plate 1053, fig. 5; Plate 1054, figs. 13, 17, 22), thick and glabrous except for a sparse pubescence of crinkly hairs on the petioles, sometimes a few of these hairs extend up on the edges of the basal lobes and very rarely stolon-leaves are found with a few hairs on the surface of the lamina toward the base. The lower and middle cauline leaves are subreniform or often with a truncate base and nearly parallel sides (Plate 1054, figs. 14, 18, 23), 5-lobed and glabrous; the two uppermost are irregularly 4–5-lobed, somewhat variable in shape (Plate 1054, figs. 15, 19, 20, 24), and with less regular adnation of their petioles to the cyme-branches. The bracts are obovate, mostly with broadly cuneate base, and 3-lobed to entire (Plate 1054, figs. 16, 21, 25).

The flowers in *C. iowense* are bright golden-yellow, short-campanulate (Plate 1054, fig. 27) and 3.5–4.5 mm. broad at anthesis; the sepals are spreading, with recurved tips (Plate 1053, figs. 2, 3), those of the outer cycle considerably broader than long and obtuse at the apex, the two of the inner cycle somewhat narrower and less bluntly rounded (Plate 1054, fig. 26), all more or less distinctly 3-nerved; disk narrow, stamens 8–5, mostly 7–6, 0.6–0.7 mm. long, styles 0.3–0.4 mm. long; mature fruit campanulate (Plate 1054, figs. 29, 30), the mouth of the dehiscing capsule even with or slightly exceeded by the sepals; the seeds are ellipsoid, 0.7–0.8 mm. long and dark reddish-brown when fully mature.

The flowers of *C. tetrandrum* are green or rarely faintly yellow-tinged, often spotted with anthocyanin, turbinate (Plate 1054, figs. 31, 32, 33), 2–2.5 mm. broad at anthesis; sepals erect, convexo-concave, with the margins and rounded tips incurved (Plate 1053, fig. 5, Plate 1054, fig. 33), all four of nearly equal size, obscurely 1-nerved, the lateral nerves either lacking or showing faint traces near the base only; disk obsolete; stamens 4, rarely 3, 0.3–0.4 mm. long; styles 0.2–0.25 mm. long; mature

fruit trumpet-shaped, the flaring mouth of the capsule overtopping the sepals (Plate 1054, fig. 36); seeds ovoid, 0.6–0.7 mm. long, bright chestnut-brown.

The principal distinguishing differences may be summarized as follows:

Flowers short-campanulate, 3.5–4.5 mm. broad at anthesis: sepals bright yellow, spreading, with recurved tips, the two outer noticeably broader and blunter than the two inner and clearly 3-nerved; stamens 8–5, mostly 7–6, 0.6–0.7 mm. long, filaments about twice as long as the anthers; seeds dark reddish-brown; radical and stolon-leaves orbicular-reniform, 7–11-lobed, stolon-leaves pubescent on both surfaces, upper and middle cauline leaves flabellate, mostly 6–7-lobed, bracts bright yellow..... *C. iowense*

Flowers turbinate, 2–2.5 mm. broad at anthesis; sepals green, sometimes faintly tinged with yellow, often with purplish spots, erect with incurved sides and tips (convexo-concave), all four of nearly equal size, obscurely 1-nerved; stamens 4, 0.3–0.4 mm. long, filaments shorter than the anthers; seeds bright chestnut-colored; radical and stolon-leaves reniform, 5–7-lobed, glabrous, except for sparse pubescence on petioles, upper and middle cauline leaves from broadly obovate to subreniform, more or less irregularly 3–5-lobed, bracts green..... *C. tetrandrum*

Although, as already suggested, *C. iowense* stands closer phylogenetically to *C. alternifolium* than to *C. tetrandrum*, it is nevertheless amply distinct from the common Old World species. One of the characters which both Rose, l. c., and Rydberg, l. c., regarded as diagnostic for *C. alternifolium* is the spotted or dotted nature of the leaves and sepals. These dots are due to the presence of internal tannin cells which occur either singly, or more often, in smaller or larger groups. In occasional herbarium specimens they are not very obvious, but by treating with ferric chloride they turn black and stand out conspicuously. I have not found any specimens of *C. alternifolium* from its entire range in Europe in which these tannin cells are lacking. In striking contrast they are entirely absent in all the material of both *C. iowense* and *C. tetrandrum* which I have studied. In the original description of *C. tetrandrum* Fries[7] described the sepals and also the carpels as being brown-dotted. In many specimens of the species, especially from the far north, the sepals, carpels and sometimes the bracts and leaves also are spotted, but here the spots are due to the presence of anthocyanin in small patches of epidermal cells and they are reddish or purplish instead of brown.

[7] Fries, Th. M. Bot. Notiser. p. 193. 1858.

They disappear completely by boiling or merely soaking in water, whereas the dots in *C. alternifolium* are a permanent feature, unaffected by boiling or treating with alcohol. When, in addition to a fundamental and unmistakable anatomical character of this kind, there are a number of stable correlating characters of flower[8] and foliage which set off *C. alternifolium* sharply from *C. tetrandrum*, it is difficult to understand why the latter has come to be regarded by many as a mere variant of the former. In raising it to specific rank, Fries, l. c., showed a better understanding of the plant than did either Maximowicz[9] or Franchet[10], the two chief monographers of the genus, and those who have followed them in treating it only as a variety. Fries knew the two entities in the field and he remarked that when he first encountered *C. tetrandrum* on a journey in Finmarken after having observed *C. alternifolium* in "full splendor" all the way through Guuldalen, he was impressed by their marked dissimilarity. He moreover emphasized that they had entirely different geographical distributions.[11]

The persistence, especially of European systematists (Hegi, Mittel Eur. Flora **4:** 2, 635; Engler & Prantl, Ed. 2, **18a,** 164. 1930) in treating *C. tetrandrum* as only a variety is no doubt largely due to Simmons', l. c., categorical statement that if sufficient material is examined the "arctic and temperate forms will be seen to be continually connected by intermediate forms". His principal argument for this dictum is the occurrence in the Arctic of plants with stamens varying in number from 4–8. He further sought to strengthen the case by maintaining that there are intermediates in respect to stature and shape of leaves. Size of plants is altogether too variable in either species to be of any significance and leaf-form is of lesser importance unless strictly corresponding leaves are compared.

[8] The flowers of *C. alternifolium* are short-campanulate, 5–6 mm. broad at anthesis; the sepals are golden yellow, spreading, recurved at the tips and 3-nerved; there is a broad nectariferous disk, regularly 8 stamens which are more than twice as long as in *C. tetrandrum*, and the styles are fully three times as long. The radicle leaves are orbicular to orbicular-reniform, 11–16-lobed (most commonly 13). The lobes are truncate or more or less deeply emarginate, with nearly straight parallel sides, giving them a rectangular to broadly cuneate shape; the thin blades are conspicuously pubescent on both surfaces.

[9] Maximowicz, A. J. Melanges Biol. IX: 762. 1876.

[10] Franchet, M. A. Nouvelle Archives d'hist. Nat. 3 Ser. II, 1890.

[11] The northernmost recorded station for *C. alternifolium* is at Overhalden, Norway, Lat. 64° 30′ N., while the southernmost occurrence of *C. tetrandrum* in Europe is around Lat. 67° 30′ N. in Sweden.

I have searched assiduously for these purported intermediates and I am unable to find any. The scores of plants of *C. tetrandrum* which I have raised from seeds from several collections made by Miss Oldenburg in the American Arctic are remarkably uniform as regards both the vegetative and reproductive tracts. I have not encountered a single individual which shows any degree of variation either toward *C. alternifolium* or *C. iowense.* The same is equally true of all the herbarium material I have studied. The plants Simmons and others have mistakenly held to be intermediate forms prove instead to be another and distinct entity, which on no other character than the variable number of stamens can be claimed to be intermediate. This entity, with prevailingly 6–7 stamens is in my opinion *C. iowense.* As long as the latter appeared to be restricted in its distribution to a limited area in northeastern Iowa, this assertion might well be open to serious question, but as already shown, it is not so limited in its range. Not only does it occur in a number of places in Alberta, but it also appears to be widely distributed in the Arctic. I have one collection made by Miss Oldenburg at Cambridge Bay, Victoria Island, which in flower, fruit and seed characters matches *C. iowense* completely. Only in its smaller size (3–6 cm.) and smaller, somewhat fleshier leaves does it differ from specimens from Iowa. I would also refer to the same species a collection by Ralph Robinson (No. 42) from Cairn Lake, Baffin Island. It is a moldy and poorly preserved specimen, but it has the open larger flowers with more than 4 stamens characteristic of the species.

In Grœntved's[12] paper on the Vascular Plants of Arctic North America there are listed several collections of *Chrysosplenium,* three of which are reported to have 6 or 7 stamens. While I have not had access to these specimens, I am of the opinion that they are not *C. tetrandrum* but low Arctic forms of *C. iowense.* From the Old World Arctic I have seen two collections which I believe belong with the latter also. One is from the Island of Vaigach by Otto Ekstam, the other from near the mouth of the Yenisei (Lat. 72° 25′ N., Long. 80° 35′ E.) by N. J. Kusnezow and W. W. Reverdatto. Both collections are identified as *C. alternifolium* which they clearly are not. They lack the charac-

[12] Grœntved, Johs., Report of the Fifth Thule Expedition 1921–24 Vol. II, No. 1. p. 47–48

teristic tannin cell dots and they have glabrous radical and cauline leaves. Some of the flowers have 8 stamens and these as well as the styles are of the same length as in *C. iowense*. The Ekstam specimen has the ellipsoid, dark reddish brown seeds and pubescent stolon-leaves characteristic of the latter. In presenting evidence for retaining the varietal status of *C. tetrandrum*, Heintze, l. c., reported finding plants at Saarikoski, Torne Lapmark, in 1904 with "stems up to 1 dm. high, very succulent, lower leaves pubescent, of the size of the head species, occasional flowers with 8 stamens". Three years later he described in detail plants from the same locality, stating that the lowermost stem-leaves were glabrous or sparsely hairy and the stolon-leaves were always pubescent, with the hairs distributed evenly and richly over the surface. The stamens were reported as 4 or seldom 3. I am inclined to doubt if Heintze was dealing with strictly one entity, for I have never yet found such a combination of characters in *C. tetrandrum* as he records. His failure to make any mention whatever of the basic differences in the shape of the flower of the two entities is also a little suspicious.

While it is obviously not safe on the present evidence to assert that *C. iowense* or a variant of it occurs in the Old World Arctic, it is certain that a form occurs there which is neither *C. alternifolium* nor *C. tetrandrum* and that this form does agree in floral and vegetative characters with *C. iowense* as it occurs in the American Arctic. Possibly this form should be treated as an arctic variety but the study of more material needs first to be made.

The isolated occurrence of the species in northeastern Iowa presents a striking case of disjunct distribution and another instance of a Pleistocene relic holding out in or on the edges of the Driftless Area. It is mostly limited to cold-water seepage places on north-facing wooded bluffs. At Brainard in Fayette County it grows at the entrance to an ice cave and in Pine Hollow, Dubuque County, at the entrance to a cool cave. The type locality has been given as Decorah but this is an error. The actual site is in the Canoe Creek Valley, six miles due north of Decorah.

In citing specimens the following abbreviations have been used: G., Gray Herbarium; I. S. C., Iowa State College; M.,

University of Minnesota; N. Y., New York Botanical Garden; U. A., University of Alberta; U. I., University of Iowa.

The following specimens of *C. iowense* have been examined: Iowa: Sect. 8, Canoe Twp., Winneshiek Co., in moss, July 1, 1888 (G., type), May 5, 1889 (I. S. C.), May 1893 (I. S. C.), *E. W. D. Holway;* same station, May 31, 1889 (M.), May 17, 1900 (M.), June 10, 1900 (M.), *A. F. Kovarik;* same station, Aug. 4, 1919 (M.), *C. O. Rosendahl* Nos. 3852, 3853; Decorah, May 5 and June 16, 1899 (I. S. C.), *Herbert Goddard;* Sect. 6, Decorah Twp., May 17, 1933 (I. S. C.), May 28, 1934 (I. S. C.), *W. L. Tolstead;* same station, growing in Mnium moss on moist talus, May 15, 1946 (M.), *C. O. Rosendahl* No. 7763; same station, May 29, 1946 (M.), *Rosendahl, Moore* and *Huff* No. 7764; entrance to ice cave, Brainard, Pleasant Valley Twp., Fayette Co., June 10, 1899 (M., I. S. C.), *A. F. Kovarik;* Pine Hollow State Park, Sect. 6, Liberty Twp., Dubuque Co., June 16, 1940 (I. S. C.), *Ada Hayden* No. 9902; same station, growing on rocks at mouth of cold cave, June 27, 1946 (M.), *Dietz, Barret* and *Young;* wooded bluff oposite Old Stone House, Allamakee Co., June 24, 1929 (U. I.), *B. Shimek.* Alberta: Elbow River, Rocky Mts., Lat. 49° 40′, June and July 1897 (G., N. Y.), *John Macoun* No. 20168; forest edge, 100 miles N. of Edmonton, May 15, 1915 (U. A.), *C. H. Turner;* east of Edmonton, May 25, 1919 (U. A.), *W. C. McCalla* No. 2665; wet places, poplar spruce grove, near Edmonton, May 26, 1926 (U. A., M.), *E. H. Moss* No. 280; near Edmonton, June 7, 1926 (U. A.), *E. H. Moss* No. 365; wet Sphagnum bog, fed by iron spring, north of McLeod Valley, about 120 miles west of Edmonton, July 21, 1945 (M.), *E. H. Moss* No. 6821; damp mossy ground under willows, near Peers, about 120 miles west of Edmonton, July 24, 1945 (M.), *E. H. Moss* No. 6864; Fort Saskatchewan, June 7, 1935 (U. A.), *C. H. Turner* No. 471; Sand Hills, 8 miles N. E. of Fort Saskatchewan, May 27, 1940 (U. A.), *C. H. Turner* No. 1670; low, wet forest trail, 9-mile point, Slave Lake District, May 31, 1929 (N. Y.), *A. H. Brinkman.* District of Franklin: wet drainage valley, Cambridge Bay, Victoria Island, Aug. 18, 1944 (M.), *Margaret E. Oldenburg* No. 921; shore, Cairn Lake, Baffin Island (G.), July 28–30, 1922, *Ralph Robinson* No. 42.

EXPLANATION OF PLATE 1053

FIG. 1, CHRYSOSPLENIUM IOWENSE, in natural habitat, near Decorah, Iowa. The pubescent stolon-leaves can be seen at the right, × ⅔; FIG. 2, the same, photographed from above, showing the wide open flowers with recurved sepal-tips, × ⅔; FIG. 3, the same enlarged to 1⅓ natural size; FIG. 4, *C. iowense*, plants grown from seed collected west of Edmonton, Alberta; note the orbicular-reniform leaves with overlapping basal lobes and nearly closed basal sinus; the pubescent stolon-leaves shown clearly near upper right hand corner, × ⅔.

FIG. 5. C. TETRANDRUM, plants grown from seed collected in the American Arctic; note the glabrous radical and stolon-leaves with open basal sinus; some of the flowers in anthesis showing the incurved sepal-tips; near the upper left-hand corner two partially developed fruits, × ⅔. FIG. 6, the same, photographed from the side, showing several flowers in anthesis, the short stems elongating somewhat after flowering, × ⅔.

EXPLANATION OF PLATE 1054

Figures 1, 2 and 33 are from living material, all the rest from herbarium specimens.

FIG. 1, seedling, of C. IOWENSE, grown from seed collected west of Edmonton, × 3; FIG. 2, seedling of C. TETRANDRUM, grown from seed collected in the American Arctic, × 3; both seedlings at same stage of development.

FIGURES 3–7 incl. are of C. IOWENSE from the TYPE-LOCALITY: FIG. 3, stolon-leaf, × 1⅓; FIG. 4, middle cauline leaf, × 1⅓; FIGS. 5 and 6, the two uppermost cauline leaves × 1⅓; FIG. 7, one of the secondary bracts × 1⅓.

FIGURES 8–12 incl. are of C. IOWENSE from Alberta: FIG. 8, stolon-leaf, × 1⅓ (*Turner* No. 471); FIG. 9, radical leaf, × 1⅓ (*McCalla* No. 2665); FIG. 10, middle cauline leaf, × 1⅓ (*Turner* No. 471); FIGS. 11 and 12, the two uppermost cauline leaves × 1⅓ (*Turner* No. 471).

FIGURES 13–16 incl. are of C. TETRANDRUM from Finland (*Justus Montell*): FIG. 13, radical leaf, × 1⅓; FIG. 14, cauline leaf, × 1⅓; FIG. 15, one of the two uppermost cauline leaves, × 1⅓; FIG. 16, one of the upper bracts, × 1⅓.

FIGURES 17–25 incl. are of C. TETRANDRUM, mostly from collections from the American Arctic: FIG. 17, radical leaf, × 1⅓ (*Butters*, Lake O'Hara, B. C.); FIG. 18, lower cauline leaf, × 1⅓ (*Oldenburg* No. 162); FIG. 19, one of the upper cauline leaves, × 1⅓ (*Butters*, Lake O'Hara, B. C.); FIG. 20, one of the uppermost cauline leaves, × 1⅓ (*Hall & Harbour* No. 576); FIG. 21, one of the primary bracts, × 1⅓ (*Oldenburg* No. 162); FIG. 22, radical leaf, × 1⅓ (*Abbe* No. 3555); FIG. 23, middle cauline leaf, × 1⅓ (*Abbe* No. 3555); FIG. 24, one of the uppermost cauline leaves, × 1⅓ (*Abbe* No. 3555); FIG. 25, secondary bract, × 1⅓ (*Oldenburg* No. 162).

FIGURES 26–30 incl. are of flowers and fruits of C. IOWENSE: FIG. 26, flower in late anthesis, × 2½ (*Moss* No. 280, Alberta); FIG. 27, early stage of fruit development, × 2½ (*A. F. Kovarik*, Decorah); FIG. 28, fruit, more advanced stage, × 2½ (*A. F. Kovarik*, Decorah); FIG. 29, mature fruit, × 2½ (*A. F. Kovarik*, Decorah); FIG. 30, mature fruit, × 2½ (*Moss* No. 365, Alberta).

FIGURES 31–36 incl. are of flowers and fruits of C. TETRANDRUM: FIG. 31, flower in anthesis, × 2.6 (*Oldenburg* No. 86); FIG. 32, flower in late anthesis, × 2.6 (*Oldenburg* No. 86); FIG. 33, flower in anthesis, × 5 (living material); FIG. 34, early fruiting stage, × 3 (*Oldenburg* No. 86); FIG. 35, nearly mature fruit, × 3 (*Oldenburg* No. 86); FIG. 36, mature fruit, × 3 (*F. K. Butters*, B C.).

UNIVERSITY OF MINNESOTA

STUDYING WILLOWS OR MAKING NEW SECTIONS IN THE GENUS SALIX

Carleton R. Ball

Recently, Fernald (Rhodora **48**: 44. 1946) has published two new sections (Uva-ursi and Argyrocarpae) in the genus *Salix*. The recognized right to publish entails responsibility for adequate information, which seems not to have been met. The equal right of discussion, and of criticism where warranted, also entails responsibilities, herein recognized. Three points should be considered in appraising the discussion.

1. Each of the two new sections contains but a single species. There are several other species in each of the two earlier sections to which these now-segregated species customarily have been assigned. In transferring a species from a plural-species section to become the type of a new 1-species section, there is obligation to show its relationship to all the species of the earlier section and not merely to the type thereof. The description and inclusiveness of a plural-species section always must be broader than those of its type species, just as the description of a plural-species genus always must be broader than that of its type species.

2. There are some 125 species of *Salix* in North America, and several hundreds in the world. Is each of them to become the type of a new section, without comparison with any except the type species of the earlier section (as in the case of *Uva-ursi*) or without any comparison whatever (as in the case of *Argyrocarpae*)? To exclude all other species from a new 1-species section because they differ from its type is no more logical than excluding new species from a genus because they differ from its type species.

3. In announcing conclusions about sections or species of a genus which is widely distributed on five continents, it seems desirable, even necessary, to consider species outside of any particular manual range. For example, the nearest relative of the writer's *S. Setchelliana*, from Alaska and Yukon, is found in the Carpathian Mtns. of southeastern Europe.

New Section Uva-ursi Fernald

This new section, based on *S. uva-ursi* exclusively, was described by Fernald as differing from *S. herbacea* L., the type

species of section *Herbaceae* Borrer, in having stems strongly ligneous, prostrate but not subterranean; branchlets leafy; leaves firm, not rounded and not conspicuously reticulate, whitened beneath; aments many-flowered; bracts conspicuously hairy; stamen usually 1.

Section *Herbaceae* Borrer (1830) was based exclusively on *S. herbacea*, the only species of the group occurring in Great Britain. It therefore could have been no broader or more inclusive than that species. Several species have been added since.

The idea of the scope of sections in *Salix* has been a gradual evolution, as have most ideas in systematic botany. From 1828 to 1866, Koch, Fries, Hartig, and Wimmer had placed *S. herbacea*, *S. polaris*, *S. retusa*, and *S. reticulata* (all the prostrate creeping willows they had in Europe) in a single section, though under three different section names. But by 1860, Kerner (NiederOst. Weid.) had placed *S. retusa* and *S. herbacea* in section *Retusae*, *S. polaris* in section *Myrtosalix* under *S. myrsinites*, and created a new genus, *Chamitea*, for the *Reticulatae* (*S. reticulata et al*).

Andersson, described by Fernald (p. 29) as "the most accurate student ever to work on *Salix*", monographed the willows of the world (DC. Prodr. **16** (2)) in 1868. In section *Myrtosalix*, he placed most of the present section *Ovalifoliae* and also *S. cascadensis* (as *S. tenera*, p. 288), *S. phlebophylla* (p. 290), and *S. uva-ursi* (as *S. Cutleri*, p. 292). In section *Retusae*, he placed *S. retusa* (p. 293) with many Asian species, and in *Herbaceae* he placed *S. herbacea*, *S. polaris*, and *S. rotundifolia*, with some Old World species, and including *S. glacialis*, which is merely juvenile *S. ovalifolia* (the type species of section *Ovalifoliae*). The two most closely related species, *S. phlebophylla* and *S. rotundifolia*, are placed in different sections.

Schneider (Bot. Gaz. **67:** 48. 1919) includes in section *Herbaceae* the following North American species: *S. cascadensis* (NW. U. S. & adj. Can.), *S. Dodgeana* (NW. U. S.), *S. phlebophylla* (NW. N. A.), *S. polaris* (circumpolar), *S. rotundifolia* (NW. N. A.), and *S. uva-ursi* (NE. N. A.). He suggested, however, that *S. uva-ursi* was widely separated by its bicolored leaves and single stamen.

In creating section *Uva-ursi*, Fernald compares the type (and only) species, *S. uva-ursi*, solely with *S. herbacea*, the only other

species of section *Herbaceae* occurring within the Manual range. No mention is made of the others, some of which are much more like *S. uva-ursi* than they are like *S. herbacea*. It seems desirable to take up the description of this 1-species section, point by point.

1. "Stems Strongly Ligneous". The five species commonly placed in section *Herbaceae* with *S. herbacea* and *S. uva-ursi* vary considerably in plant size but all of them have the ligneous prostrate stems, not or only partly subterranean, often "forming extensive superficial and very leafy carpets", as Fernald said of *S. uva-ursi*. *S. polaris* is more nearly like *S. herbacea*. The other four are more like *S. uva-ursi*. Several authors speak of the stems of these others as being partly subterranean. Furthermore, *S. herbacea* is not always a delicate plant with slender stems. Dutilly 6605 (Herb. Ball) from Chesterfield Inlet has stout and strongly ligneous stems to 4 mm. thick, and other specimens have stems anything but delicate.

2. "*Branchlets Leafy*". Both species and section Uva-ursi are described as having "leafy branchlets", while *S. herbacea* is said to have short branchlets with only 3–4 leaves. Most species have fewer leaves on short branchlets and more on longer ones. That holds for all those assigned to section *Herbaceae*. Linton, a lifelong personal student of willows, says (Mon. Brit. Willows, p. 79. 1913) that the short branchlets of *S. herbacea* have 3–5 leaves. My Iceland specimen, specially collected by Wm. F. Palsson (No. 146) in 1939, has 5 branchlets with 6 leaves each and 2 branchlets with 7 leaves each. *S. polaris* shows about the same numbers. It is more similar in habit to *S. herbacea* while the other four are more similar to *S. uva-ursi*.

3. "Leaves Firm". The leaves of *S. uva-ursi* (*S. Cutleri*) undoubtedly are firm, Andersson (1868) calling the adult leaves extremely rigid. But the leaves of *S. phlebophylla*, *S. rotundifolia*, *S. Dodgeana*, and *S. cascadensis* also are firm. Of *S. phlebophylla*, Andersson said (1868, p. 290) that the leaves are coriaceous but, more strangely, he called those of *S. polaris* "coriaceo-rigidibus" also. The leaves of *S. phlebophylla* remain attached and skeletonizing for 2 or 3 years. For section *Herbaceae*, Andersson described the leaves as "coriaceo-indurata".

4. "Leaves Not Rounded". They also are not rounded in some of the other species of *Herbaceae*. *S. phlebophylla* has

obovate-spatulate or elliptical-spatulate leaves, *S. Dodgeana* has smaller but similar elliptical-obovate leaves, while those of *S. rotundifolia* are roundish. These three are very closely related. *S. cascadensis* has linear-oblong or narrowly elliptical leaves. Of the seven related American species, three have leaves more or less roundish and four have not.

5. Leaf Margins. *S. uva-ursi* and *S. herbacea* are alike in having the blades crenulate-serrulate, a fact not mentioned by Fernald. The serrations of *S. herbacea* sometimes are prolonged and inflexed. *S. polaris* has the blades sometimes slightly crenulate-serrulate. The others have entire leaves.

6. "Leaves Not Conspicuously Reticulate". Study of 47 specimens of *S. uva-ursi* (Herb. Ball), 20 from New England and Lower Canada and 27 from Labrador Peninsula, shows that, practically without exception, their leaves are reticulate on one or both surfaces. "Reticulate" is used here as showing prominent tertiary veins connecting the secondary (lateral) veins, and so forming nets. On specimens collected early in the season, reticulation is not well developed but even then conspicuous reticulation will be found on the lower surface of several leaves and on the upper surface of one here and there. Its prominence increases as the season progresses and the leaves become older, many collections showing the lower surface conspicuously reticulate and the upper becoming more so. Collections in late August and September usually show both surfaces prominently reticulate, resembling those of *S. ovalifolia*. Andersson (1868, p. 292) stated that the leaves of *S. uva-ursi* (*S. Cutleri*) had the elevated nerves reticulate beneath, just as he said for both surfaces of *S. herbacea* (p. 298).

All of the species under discussion have the secondary (lateral) veins prominently developed. All of them show a tendency to become reticulate with age, especially *S. phlebophylla*, which is most comparable to *S. uva-ursi* in habit, and in size and shape of leaves, and in progressive reticulation also. The leaves of *S. rotundifolia*, though smaller, show exactly the same range of reticulation, and those of *S. Dodgeana* show it also but less markedly. These three are most closely related to *S. uva-ursi*. Even the long slender leaves of *S. cascadensis*, with the secondaries closely crowded, show occasional reticulations on one or other side of individual leaves.

7. Leaves "Whitened Beneath". The leaves of *S. uva-ursi* are glaucescent ("whitened") beneath, whereas those of *S. herbacea* and the others species under discussion normally are green beneath. However, *S. cascadensis*, which extends from Wyoming and Utah to Washington and British Columbia, produces plants with some of the leaves glaucescent beneath throughout its range. No plant with all leaves glaucescent has been noted. Coville (Will. of Alaska) says that the leaves of *S. polaris* are green or somewhat glaucescent beneath, but the writer has not observed such glaucescence.

But Section *Lucidae* has green-leaved species (*S. lucida* and *S. caudata*) and glaucous-leaved species (*S. serissima* and *S. lasiandra*), the first member of each pair being eastern (manual range) and the second western. Section *Cordatae* also has green-leaved species (*S. myrtillifolia, S. monochroma* and *S. pseudocordata*) and glaucous-leaved species (*S. cordata* Muhl., *S. Farrae, S. ligulifolia, S. lutea* and *S. mackenziana*), the first-named species in each group occurring in the manual range. And Fernald himself named a glaucous-leaved variety (*brachypoda*) of green-leaved *S. myrtillifolia*. He also named a widely-distributed glaucous variety (*hypoglauca*) of the narrowly localized green-leaved *S. pedicellaris* Ph. Evidently, glaucousness need not be uniform in sections.

8. Petiole Length and Thickness. The leaves of *S. uva-ursi* were said to be "short-petioled" (not included in section description) while those of *S. herbacea* were described as "slender-petioled". These are not truly contrasting terms. Gray's Manual does not mention the petioles. Those of *S. herbacea* are described in Britton and Brown (Illus. Fl.) and Britton (Man.) as "very slender, 4–8 mm. long" and those of *S. uva-ursi* as 2–4 mm. long.

A study was made on 57 specimens of *S. herbacea* (Herb. Ball), 7 from south of the St. Lawrence and 50 from north of it. In the southern plants the petioles were from 1–4 or occasionally 5 mm. long and mostly stout. On the 50 northern plants the leaves average smaller and the petioles shorter, mostly 1–3 mm., occasionally 4 mm., and only once reaching 5 mm. In width, they varied from 0.3–1 mm., and mostly between 0.5–0.6 mm., which is not "slender" for organs of those lengths. Gardner

176 from Cut-throat Id., Labrador, has leaves to 2.2 cm., and petioles to 3–5 mm. long and 0.8 mm. wide (stout). Gardner 1075 from Hudson Bay has petioles 2–3 mm. long and 0.7 mm. wide. Potter & Brierly 8727 from Eclipse Harbor, Labrador, has petioles 3 mm. long by 1 mm. wide. In European *S. polaris*, closely related to *S. herbacea*, the petioles range from 1–3 or 4 mm. long.

On 20 specimens of *S. uva-ursi* (Herb. Ball) from New England and Lower Canada, the petioles average just a little less in width than those of *S. herbacea*. Of the two, therefore, *S. uva-ursi* really has the "slender" petioles.

9. "Aments Many-Flowered". The aments of section *Uva-ursi* are described as "many-flowered", while *S. herbacea* is said to have "2–8-flowered tiny aments". In Gray's Manual (1908), the aments of *S. uva-ursi* are described as 2–3 cm. long in fruit, while those of *S. herbacea* are said to be 4–10-flowered, on 2-leaved branchlets. Britton & Brown (Ill. Fl., in 1896) and Rydberg in Britton (Man., in 1901) both describe the pistillate aments of *S. uva-ursi* as 2–5 cm. long in fruit, and the aments of *S. herbacea* as 4–8 mm. long and 4–10-flowered, on 2-leaved branchlets.

Andersson (in DC. Prodr. **16**) in 1868, is not definite about ament size on the 6 species included but he does say that those of *S. herbacea* (p. 298) are 3–12-flowered, on usually 2-leaved (subbifolios) branchlets, and that those of *S. polaris* (p. 299) are 3–9-flowered. In 1858, however, he stated (Sal. Bor.-Am.) that the aments of *S. uva-ursi* (*S. Cutleri*) are an inch long and that those of *S. phlebophylla* (p. 73) are minute to ½ inch or 1 inch long. Wimmer (Sal. Europ.), in 1866, not concerned with American *S. uva-ursi*, recorded the aments of *S. herbacea* as 4–12-flowered, *S. polaris* as few-flowered, *S. retusa* as 4–15-flowered, and *S. reticulata* as many-flowered. Linton, a life-time student of British willows, stated (Monog. Brit. Will., p. 79. 1913) that the catkins on *S. herbacea* are ½–¾ inch long, the pistillate 3–12-flowered and rarely elongating to nearly an inch. This is not exactly "tiny".

Most of the 57 specimens of *S. herbacea* in Herb. Ball are late-collected and do not have fruits. The mostly depauperate Labrador specimens have at least 8 flowers and perhaps more.

One from Campbell Lake, NWT. (Radford 186) has 10 or more. Steinmetz 1134 from Mt. Katahdin, Me., has aments 1 cm. long and with 10 or more flowers. Merrill from Mt. Katahdin in 1898 has one ament 1.7 cm. long (not tiny), and with 12 or more flowers. It is difficult to count the capsules on mounted specimens without injuring them. European specimens of *S. herbacea* in my herbarium are 8–14 flowered. A vigorous Iceland specimen is 10–16- (or 17)-flowered (double the number allowed by Fernald) and the aments are up to 1.5 cm. long, which scarcely is "tiny".

10. Two-Leafed Peduncles of S. Herbacea. Fernald draws no distinction between *S. uva-ursi* and *S. herbacea* on this point. However, Andersson referred to the peduncles of *S. herbacea* as "subbifolios" and most later writers have called them "2-leaved". One Hungarian specimen in Herb. Ball shows 3 leaves and the Iceland plant has 3–4 leaves per peduncle.

11. "Bracts Conspicuously Hairy". The flower scales in new section Uva-ursi are described as "conspicuously silky" and those of *S. herbacea* as "nearly glabrous". Andersson in 1868 said that the bracts of *S. herbacea* were glabrous or gray-pilose and Linton in 1913 calls them glabrous or thinly pubescent. But in 1868, Andersson, "the most accurate student ever to work on *Salix*" (Fernald, p. 29), calls the bracts of *S. uva-ursi* (*S. Cutleri*) obscurely villose; those of *S. polaris* "glabris vel villosulis"; those of *S. phlebophylla* white-pilose or barbate; those of *S. rotundifolia* as sufficiently long-ciliate; and those of *S. cascadensis* (*S. tenera*) as long-pilose. Do the white-pilose bracts of *S. phlebophylla* and the long-ciliate bracts of *S. rotundifolia* put these two intimately related species in different sections?

12. "Stamen Usually 1". The staminate ament of section Uva-ursi is described as having "stamen usually 1", and *S. uva-ursi* as having "stamens solitary (rarely 2)". Schneider says (p. 50) that he has "very rarely found two stamens in one flower". The uni-staminate condition is found to about the same degree in *S. purpurea*, the European basket willow widely introduced in Colonial America. It also characterizes *S. sitchensis* and *S. Coulteri* (section *Sitchenses*), and occurs occasionally in other diandrous species.

It is a phenomenon of the *Diandrae* only and is caused by more

or less complete fusion of the two filaments. When the "rarely 2" stamens occur, the union has not taken place. But the staminate expression is not as simple as that. All degrees of fusion occur. The two filaments may be entirely separate, as noted, or they may be united for any fraction of their length (¼, ½, ¾, ⅞) or all of it. Sometimes when the filaments are completely united, there still will be two separate anthers. Sometimes these also will be united into one. The partial union of the 2 filaments occurs in numerous species of the *Diandrae* and usually is described as "filaments sometimes united at base" or "for part of their length".

In Summary. The characters alleged to separate section Uva-ursi from *S. herbacea* (type species of section *Herbaceae*) have been reviewed above, in comparison with those of five related North American species usually assigned to section *Herbaceae*. From the data presented, it is clear that either: (1), section *Uva-ursi* must be rejected outright; or (2), some four other American species must be added to it and the description completely rewritten. But first it must be decided whether there is sufficient difference between two groups in these seven species to warrant recognition of two separate subsections or sections. These two groups include *S. herbacea* and *S. polaris*, on the one hand, and *S. uva-ursi*, *S. phlebophylla*, *S. rotundifolia*, *S. Dodgeana*, and *S. cascadensis*, on the other. That decision, however, will require full study of many related European and Asian species. Such study has not been made.

New Section Argyrocarpae Fernald

In creating section *Argyrocarpae*, Fernald says merely that the type species, *S. argyrocarpa*, "stands so far apart from other willows that it deserves a place in the system of sections". This is dogmatic assertion, not science. No supporting facts are given, except that Schneider, whom Fernald had just previously denounced (p. 14) as the author of "what has been called this Schneid. treatment" of certain American willows, is here rehabilitated as a "close student of the genus" because he did not assign *S. argyrocarpa* to any existing section.

This new section includes only *S. argyrocarpa* Andersson, and the description reads: "Shrub 0.2–1.7 m. high; leaves shining-

silky (micaceo-sericeis) beneath; pedicels elongated, 2–4 times as long as the two glands; stamens 2." Actually, instead of being "far apart from other willows", it is a blood brother to *S. pellita*, also of the Manual range, and closely related to *S. bella*, *S. Drummondiana*, and *S. subcoerulea* of western America. It is not distantly related to four or five other species. Previous treatments are discussed below.

Andersson, in 1867 (Monog. Sal., pp. 106 & 125) and 1868 (in DC. Prodr. **16** (2): 233 & 240), described two sections: 11, *Argenteae* or *Repentes*, and 12, *Virentes* or *Phylicifoliae*, and arranged all of the then-known American species of section *Argenteae* in one or the other of the two. He described each section briefly but only a few really contrasting characters are given. These contrasts are noted below, with a few significant but non-contrasted characters included in parentheses.

Sect. 11, Argenteae or Repentes. Shrub often low; leaves long, linear-lanceolate, most often silvery-tomentose (sharply nerved above), margin revolute or serrate; aments subsessile; capsules more or less pedicelled, commonly sericeous; style short but distinct.

Under this section, Andersson arranged numerous species belonging to five more or less different groups: 1, *S. sitchensis*, the type species of section *Sitchenses;* 2, *S. argyrocarpa*, the subject of our discussion, of which more later; 3, *S. petiolaris*, and thereunder, as subspecies or varieties, *S. subsericea*, *S. gracilis*, and *S. sericea*, at present recognized as species or varieties; 4, *S. humilis* and *S. tristis*, commonly assigned to section *Capreae* (along with *S. discolor*, *S. Scouleriana*, and the European *S. caprea* and *S. cinerea*, grown in America as florists' willows); and 5, the little European *S. repens*, along with other Old World species.

Sect. 12, Virentes or Phylicifoliae. Shrub often tall; leaves broad, subobovate or ovate-lanceolate, commonly glabrous, (glaucescent below), remotely inflexed-serrulate, nerves subparallel; aments subsessile; (bracts black-tipped, pilose), capsules pedicellate, (conic-rostrate); commonly silky (called "glabrous or tomentose" in 1867. CRB.); style rostrate.

Four groups of American willows were assigned by Andersson to this section: 1, *S. phylicifolia* (*S. planifolia* Ph.), *S. fulcrata*

and *S. phylicoides* (both *S. pulchra*), these and other American and Old World species actually comprising section *Phylicifoliae;* 2, *S. Drummondiana* and *S. chlorophylla* Anders. (the latter including present *S. pellita* Anders. and *S. subcoerulea* Piper), all belonging to section *Argenteae* and discussed more fully later; 3, "*S. macrocarpa* Nutt.", which, whatever it was, obviously was not Nuttall's plant (*S. Geyeriana* Anders.); and 4, *S. humillima* (*S. arbusculoides* Anders.), also discussed later on. He included also *S. arbuscula* L., and many other Old World species.

Under these two section names, Andersson thus assembled a miscellaneous mass of species actually belonging to several widely different sections of the genus. He should not be too severely blamed for this confusion. He was attempting the impossible task of writing up the willows of the world (for DC. Prodr.) in a limited time, and with inadequate material probably not all before him at one time.

Much inaccurate description results from these two groupings of unrelated species. For example, his *Argenteae* are assigned long, linear-lanceolate leaves but those of *S. sitchensis*, *S. humilis*, and *S. tristis* are distinctly oblanceolate and narrowed at the base, and in the first two species often broadly oblanceolate and cuneate. The leaves also are described as strongly nerved above but those of *S. argyrocarpa* are just the opposite. In section *Phylicifoliae*, the leaves are described as broad, subobovate or ovate-lanceolate, and also are said to be "commonly glabrous" (the real *Phylicifoliae*). But those of *S. pellita* and *S. arbusculoides* are narrowly lanceolate and those of both *S. pellita* and *S. Drummondiana* are among the most densely hairy of American willows. The "conic-rostrate capsules" really occur on *S. humilis* and *S. tristis*, listed in section *Argenteae* but not belonging to either section.

Eight (or 9) of the ten (or 11) North American species commonly assigned now to section *Argenteae* are scattered at intervals, by Andersson, through both his *Argenteae* and *Phylicifoliae*. Only four (or 5), *S. argyrocarpa*, *S. petiolaris* (and *S. gracilis*), *S. sericea*, and *S. subsericea*, were placed in *Argenteae*. Four others, *S. arbusculoides*, *S. Drummondiana*, and *S. chlorophylla* (covering both *S. pellita* and *S. subcoerulea*) were placed in *Phylicifoliae*. These 8 (or 9) species, with two others not known

to Andersson (*S. bella* Piper and *S. coactilis* Fernald), may be divided into two natural groups. Some may regard these groups as representing subsections and some as representing sections. In either case, the species of each group belong together.

The first group is characterized by leaves with margins revolute and either entire or sparingly undulate-crenulate, the lower surface mostly densely velutinous or silvery-tomentose, the extra-numerous secondary veins impressed in the upper surface, prominently elevated beneath, and diverging from the midrib at relatively broad angles, like the ribs of a vertebrate. Here belong *S. argyrocarpa*, and *S. pellita* of the Manual range, and *S. bella*, *S. Drummondiana*, and *S. subcoerulea* of the Rockies and/or westward. Of these, only *S. argyrocarpa* is placed by Andersson in *Argenteae*, where it belonged.

The second group is characterized by leaves serrate or serrulate on the non-revolute margins, the lower surface densely to thinly covered with short silvery hairs or somewhat glabrate, the secondary veins of normal number and elevated on both surfaces. and diverging from the midrib at the usual sharper angles. This groups includes *S. arbusculoides* (far Northwest) and *S. coactilis* Fern. (unknown to Andersson), *S. petiolaris*, *S. sericea*, and *S. subsericea* (all Manual range). Only *S. arbusculoides* was placed in *Phylicifoliae* by Andersson.

Schneider, 50 years after Andersson, and with much more copious material, did almost as illogical a job (Jour. Arnold Arb.). He follows Andersson in dividing these related species between two sections. In section *Griseae* (*Argenteae*), he placed (**2**: 13–25. 1920) *S. sericea*, *S. coactilis*, and *S. petiolaris*, but omits *S. argyrocarpa* from both sections. He also adds, as did Andersson, *S. humilis* and *S. tristis*, both belonging to section *Capreae*. In section *Phylicifoliae* (**1**: 67–91. 1919), with the several species really belonging thereto, he placed *S. bella*, *S. Drummondiana*, *S. pellita*, and *S. subcoerulea*, but omitted *S. arbusculoides* from both sections.

Still later (**2**: 84–89. 1920), he treats both *S. arbusculoides* and *S. argyrocarpa* at great length but is unable to assign them to any existing section. Like Fernald, he gives no reason why he could not place each with its respective group, even if he could not unite the two groups. Like Andersson, Schneider was attempt-

ing the impossible task of a monograph of unfamiliar American willows in limited time and under conditions of physical and mental stress (he was interned, on meager pay, with an otherwise unsupported family in Germany).

There is nothing in Andersson's descriptions of his *S. argyrocarpa* and *S. pellita* which indicates other than closely related species. Andersson compared them himself and rejected close relationship because *S. argyrocarpa* had pedunculate aments and pedicelled capsules whereas *S. pellita* had sessile aments and short-pedicelled capsules. Yet Andersson, in 1868, reduced *S. sericea* to a variety of *S. petiolaris*, although the latter had leafy-peduncled aments and long-pedicelled capsules while *S. sericea* had almost sessile aments and short-pedicelled capsules! Why should the same two characters which permitted one pair of distinct species to be arranged as a species and its variety prevent another pair, much more alike vegetally, from belonging to the same section? Such decisions are sheer nonsense, and it is not clear why Schneider and Fernald chose to follow them.

Both *S. argyrocarpa* and *S. pellita* have narrow leaves with revolute margins, the nerves impressed above and prominent below, the numerous secondaries diverging from the midrib at broad angles, and the blades covered densely with long silvery hairs at first but often becoming quickly and unevenly glabrate to glabrous. These facts should have brought recognition of their very close relationship long ago. On three sheets of unnumbered specimens of *S. pellita*, collected by Fernald at Ft. Fairfield, Me., on June 5, 1901 (Herb. Ball), different portions could be described as varieties based on degrees of pubescence or its absence. The same variation is seen commonly on *S. argyrocarpa*.

In Conclusion

1. The whole purpose of botany, including taxonomy (but not synonymy) is to enable more people to know more about more plants. That purpose is not served by dogmatic assertions without supporting facts. Only useless, confusing, and expensive synonymy is increased thereby.

2. If more living plants and more herbarium specimens were studied more thoroughly, there would much more knowledge and fewer names.

3. If keys were constructed primarily on vegetal characters, representing the major portion of the organism and present throughout most or all of the year, instead of floral characters (soon gone with the wind), willows would be much better known.

Extension Service,
United States Department of Agriculture

Unverified Bibliography of Scirpus.—Thinking to add to the *Manual* treatment the names of sections under *Scirpus*, I automatically and very naïvely turned to the enumeration of sections in Beetle's *Studies in the Genus Scirpus VII, Conspectus of Sections represented in the Americas*, in Am. Journ. Bot. xxxi. 261–265 (1944). I should have known what to expect, after having been obliged to analyze the work of that ambitious author on morphological characters and elementary geography and other details[1]; but I imagined that, after pretty severe criticisms of his wholesale lack of precision, his work would have become more accurate. Most unfortunately, however, I was in for further disillusionment; and, since too many students, uncritically accepting what they see in print, especially when it has passed the Editorial Committee of the American Journal of Botany, are likely to suppose (as I did) this Conspectus of the sections of *Scirpus* to be authoritative, it becomes an unwelcome duty to designate some of the most misleading points. This I do as briefly as is consistent with clarity, Beetle's sectional bibliography repeated in smaller type, this followed in 9-point by statement of a few mere facts.

(1) Section Oxycaryum Nees, Mart. Fl. Bras. 2: I. 90. 1847 . . . . . based on *Scirpus cubensis* Poepp. & Kunth.

Nees in Martius, Fl. Bras. ii[1]. (1842—not 1847) defined his new genus (not section) *Oxycaryum* with a single species, *O. Schomburgkianum*, named for the famous collector, the type from British Guiana.

(2) Section Monocephales Clarke, Kew Bull. Add. Ser. 8. 111–113. 1908.

C. B. Clarke (not one of the earlier Clarkes) in vol. viii of the Kew Bull. Add. Ser. enumerated all the 10 sections of *Scirpus* which he recognized in the entire world. Two to five sections were defined, with typical

[1] See Rhodora, xliv. 479–484 (1942) and xlv. 279–296, especially pp. 279, 280, 284, 290 and 291 (1943).

species cited, on each page, but none of them stretched over pp. "111–113". On p. 111 Clarke defined his *Scirpus*, sect. Monostachyae but I find no sect. "*Monocephales*" nor any other section beginning *Mon;* and there are none ending "*cephales*". Not one of the four species placed by Beetle in his wrongly ascribed, wrongly spelled and wrongly constructed § "*Monocephales*" was mentioned by Clarke under his § *Monostachyae.*

(3) Section Reigera Opiz. Sezman 83. 1852.

Opiz (not an abbreviation), in a mere list of names, in his Seznam (not Sezman), these quite without a word of description and with *Reigera* defined only by having its single binomial based on *Scirpus maritimus* L., obviously published a *nomen nudum*, his generic name being illegitimate. That is not the definition of a section!

(4) Section Nemocharis Beurl. Bot. Notiser Pl. Ind. Occ. 13. 1825.

Just what "Bot. Notiser Pl. Ind. Occ." may be I do not know; neither did Pritzel nor Urban (Symb. Antill. i. 12). According to the Royal Society Catalogue Beurling's first paper was published in 1842. So, turning to the well known Swedish Botaniska Notiser, we find in the volume for 1853 Beurling's new genus (not section) *Nemocharis*, based on *Scirpus sylvaticus*, properly defined on p. 52, the binomial on p. 53. That was not as a section; but in his Plantae Vasc. seu Cotyl. Scand. 55 (1859) Beurling divided *Scirpus* into two subgenera: "**Scirpus Linn. a. Nemocharis Beurl.**" (with citation of Bot. Not. l. c.); and **"b. Euscirpus"** with two sections, "*α. Phyllantheli:* 2. S. maritimus Linn. . . . . *β. Cladanthei:* 3. S. lacustris Linn." The section including *S. sylvaticus* is § *Phyllothryon* Döll. Fl. Baden, i. 305 (1857), also § *Phylloscirpus* Pax, l. c. (1887).

(5) [Section] Androcoma Nees, in Hook. Jour. Bot. 2: 1. 91. 1847.

The bibliography is as bad as in the other cases. In Hook. Journ. Bot. ii. 396 (1850) *Androcoma* was first described, as a new genus (not a section). § *Androcoma* (Nees) Benth. in Benth. & Hook. Gen. Pl. iii. 1051 (1883) includes, as treated by Pax in Engler & Prantl, Nat. Pflanzenf. ii^2. 112 (1887), the three genera of Nees: *Androcoma*, *Blepharolepis* and *Oxycaryum.*

(6) Section Trichophorum Pers. Syn. Pl i: 69. 1805.

Persoon did not make a section, but with absolute clarity published the genus *Trichophorum* with three species: *T. cyperinum*, based on *Eriophorum cyperinum* L.; ? *T. lineatum*, based on *Scirpus lineatus* Michx.; and *T. alpinum*, based on *Eriophorum alpinum* L. These belong in three different sections as now understood. In 1823 Mertens & Koch, in Röhlings Deutschl. Fl. i. 452, made the subgenus *Eriophorum* subgen. *Trichophorum*, consisting in Germany only of *E. alpinum*, the other two species of Persoon's genus *Trichophorum* being strictly North American. Dalla Torre & Harms (p. 31) consider this treatment an emendation of Persoon's original and that the subgenus consists solely of *E. alpinum;* consequently, by their reasoning, *Trichophorum* (emended) is strictly *Eriophorum alpinum.* Several botanists have accepted this interpretation, but it should be noted that Mertens & Koch did not materially alter

the definition of *Trichophorum* and in a flora of Germany they could include only *Eriophorum alpinum;* they could not include Persoon's other two species because they do not grow in Germany.

The next important change was that of Nees, in his highly significant *Uebersicht der Cyperaceengattungen* in Linnaea, ix. 293 (1834), who redefined the genus *Trichophorum* to include only *T. cyperinum* (L.) Pers. That, unlike the treatment of Mertens & Koch, was a true emendation of the genus and may be accepted as fixing the restricted application of the name. Kunth, in his philosophical discussion, *Über die Linnéischen Gattungen Scirpus und Schoenus,* in Berlin. Abhandl. (1835) 40, promptly accepted this emendation and called "*Trichophorum cyperinum* Pers. . . . dem Typus der Gattung". Later, Bentham, l. c. 1052 (1883), although holding all three of the original species as segregated by Persoon, split *Eriophorum* into two sections: "Genus quoad setas hypogynas in sectiones 2 parum naturales dividitur:—1. *Trichophorum,* setis 6 tenuissimis longe crispo-flexuosis vix tamen gossypinis". That was, apparently, the first treatment of *Trichophorum* as a section, although under *Eriophorum.* The first use of § *Trichophorum* in the sense of *Scirpus cyperinus* L. (the type of *Trichophorum*) and under *Scirpus* appears to be the quite unwitting one of Beetle in Am. Journ. Bot. xxxi. 264 (1944). Since he there cites the original Persoon reference and defines (in English) the characters of the section, we may assume that his section is the same as *Eriophorum* § *Trichophorum* (Pers.) Benth. If someone who fully realized what he was doing had earlier made the proper combination, as a sectional name under *Scirpus,* I have missed his publication. It seems too bad to saddle upon an author a combination which he did not know he was making.

(7) Section Baeothryon Ehrh. 4: 147. 1789.

Assuming that "Ehrh. 4" means Ehrh. Beitr. iv. and turning to that volume one comes to Ehrhart's 100 *monomials* which are explicitly cited as illegitimate and having no nomenclatural status in Art. 67 (3) of the International Rules of Plant Nomenclature. The name *Baeothryon,* however, although illegitimate when published by Ehrhart (certainly not as a sectional name), was properly published with diagnosis as a true GENERIC NAME by A. Dietrich, Spec. Pl. ii. 89 (1833). Nomenclaturally the name starts with A. Dietrich. Although Ehrhart was certainly not the author of *Scirpus,* § *Baeothryon,* that combination was properly published by Endlicher, Gen. 118 (1836).

(8) Section Eleogiton Link, Hort. Berol. 1: 293. 1827.

As one might expect to find, *Eleogiton* was defined by Link as a GENUS, not a section, and on p. 284 (not 293). It is *Scirpus,* § *Eleogiton* (Link) Reichenb. Icon. Fl. Germ. viii. 38 (1846), as § *Heliogiton.*

(9) Section Isolepis R. Br. Prod. Fl. N. Holl. 221. 1810.

As all critical students of the taxonomy of the *Cyperaceae* know, Robert Brown defined a GENUS (not a section), this later becoming *Scirpus,* subgen. *Isolepis* of Benth. in Benth & Hook. l. c. 1050 (1883), also of Pax and other authors (some presumably much earlier). § *Isolepis* (R. Br.) Reichenb. l. c. 39 (1846) is at least safe, although it is possible that the

section was properly named earlier than in 1846. It certainly was not so treated by Robert Brown.

(10) Section Actaeogeton Reich. Icon. Fl. Germ. Helv. 40. 1846.

Reichenbach's Icones consisting of 24 large volumes, published from 1834 to 1909, exact bibliography would seem to call for the number of the volume. In vol. viii. 40 (1846) Reichenbach placed the annual *Scirpus supinus*, along with other annual species, in his § *Isolepis*. His next section was § *Schoenoplectus*, a series of mostly stoloniferous perennials; and under that section his first subsection (not section) was subsect. *Actaeogeton*, consisting of the single coarse Old World *S. mucronatus* L. These plants belong to *Scirpus*, § *Schoenoplectus* Reichenb. l. c. They are *Scirpus*, § *Eu-Scirpus*, C. B. Clarke, l. c. 112 (1908), with sub-§§ *Mucronatae* (*S. supinus* L., *mucronatus* L., *americanus* Pers., *Olneyi* Gray and their allies), *Lacustres* (*S. lacustris* L. and many others) and *Littorales* (*S. riparius* Presl, etc.). The § *Actaeogeton* Reichenb. emend. Beetle, Am. Journ. Bot. xxix. 653 (1942) seems to be a fairly clear section. Since Reichenbach treated it as a subdivision of the genus, it may be cited as of Reichenb. emend Beetle, l. c.

(11) Section Schoenoplectus Palla, Sitzb. Zool. Ges. Wien. 38: 49. 1888.

Since *Scirpus*, sect. *Schoenoplectus* was definitely published by Reichenb. l. c. 40 (1846), the section taken up under that name by Benth., l. c. 1051 (1883), by Pax, l. c. 112 (1887), and by Dalla Torre & Harms, Gen. Siph. 31 (1900), it is a bit unusual to cite it as starting in 1888.

(12) Section Pterolepis Schrad. Goett. Gel. Anz. 3: 2071. 1821.

Pterolepis Schrad., as one has learned to expect, was published by him as a genus. Its members are placed by Reichenbach, Bentham, Pax, and Dalla Torre & Harms in § *Schoenoplectus*. If kept apart it is *Scirpus* § *Pterolepis* (Schrad.) Endlicher, l. c. (1836).

(13) Section Holoschoenus Link, Hort. Berol. i. 293. 1827.

Again a genus of Link's, said to be his section. The section started as *Scirpus*, sect. *Holoschoenus* (Link) Koch in Linnaea, xxi. 619 (1848).

The sectional names which I have here taken up are not, necessarily, all final. I can not take the weeks of time to follow them through to absolute finality. That is a task for a competent specialist on *Scirpus*, when he appears. For the present, however, their bibliographic bases are more certain than the large portion (essentially 100 per cent.) of error which pervades the unfortunate publication which induced these memoranda.—M. L. Fernald.

Some Noteworthy Catskill Plants.—The presence of several plant species of boreal affinity in the Catskill Mountains, New York, where they are comparatively isolated, seems worthy of mention.

In 1943, Mr. Edward M. Shields published a delightful article entitled *Porcupines and Ferns* [Am. Fern. Jour. **33** (2): 57–59], in which he described the finding of *Dryopteris fragrans* (L.) Schott var. *remotiuscula* Komarov (as *D. fragrans*) in the Catskills. As this represented a considerable range extension, the writer was glad to join Mr. Shields and Dr. Edgar T. Wherry on June 24–26, 1946, in a further search for this species and associated plants.

We investigated a number of cool, moist, north-facing ravines in the vicinity of Haines Falls, Greene County, and found the object of our search growing profusely in several of them, together with a few plants of typical *Lycopodium selago* L. and large quantities of *Sedum roseum* (L.) Scop.

The nearest previously known localities for *D. fragrans remotiuscula* are north-central Vermont, the Adirondack region, and various points around the Great Lakes. *L. selago* ranges further south on the higher peaks of New England, and is found at several widely separated localities in the Appalachians, south to North Carolina. *S. roseum*, like the others, is a circumpolar boreal species with a very sporadic range in northeastern United States, being known along the coast of Maine, at two localities in Vermont, at Chittenango Falls, Watkins Glen and Seneca Lake, N. Y., opposite Port Jervis and at Nockamixon Rocks, both along the Delaware River in Pennsylvania, and at Roan Mountain, North Carolina.

At the Haines Falls, New York, locality of the above it was noted that the soil about the roots of these plants was slightly acid, with a pH of 6 as determined by several readings. At Haines Falls itself, where the moist, overhanging cliffs have long been known to support such plants as *Woodsia glabella* R. Br. and *Cryptogramma stelleri* (Gmel.) Prantl, the soil, as well as the water dripping from the cliffs, was neutral with a pH of 7. Growth conditions at the two places seemed identical except for the slight difference in pH, yet the distinction apparently is sufficient to prevent intermingling of the two groups of boreal species.

Pressed specimens of all the above plants have been deposited at the Academy of Natural Sciences of Philadelphia.—George R. Proctor, University of Pennsylvania.

THE USE OF FORMALDEHYDE IN PLANT COLLECTING[1]

Richard Evans Schultes[2]

The preparation of plant specimens for the herbarium is not a difficult task. The usual procedures, however, are sometimes awkward to apply or unsatisfactory under certain conditions. Such is the case, for example, in unfavorable tropical climates or when treating certain groups of plants in which immediate and rapid drying causes undesirable changes in the plant tissues, resulting in the disintegration of the specimen upon subsequent handling.

As is well known, the general procedure is to dry plant specimens in the field. Some botanists are accustomed to use gasoline pressure stoves, in which case the plant press, with the specimens between blotters and corrugated metal or cardboard sheets, is suspended above the source of heat so that currents of hot air pass up through the corrugated sheets. The position of the press is changed from time to time, and the specimens dry rapidly, requiring from two to forty-eight hours, depending upon the texture and fleshiness of the tissues.

Other botanists prefer to dry more slowly, placing the press of corrugated sheets with plants in the sun so that the specimens dry gradually with solar heat and wind which circulates between the corrugates.

In my opinion, specimens prepared by these two procedures in the field can be of equally high quality. If the specimens be carefully prepared, one usually cannot distinguish those dried rapidly with artificial heat from those dried slowly with solar heat. The difference between the two methods is not in the

[1] Translation from the Spanish, by the writer, of an article entitled: "El uso de formol en la recolección de plantas" which appeared in the *Revista de la Facultad de Agronomía* (Medellín, Colombia) vol. vi, no. 22 (1946) 46–52.

[2] Agent (Botanist) United States Department of Agriculture; Research Fellow, Harvard Botanical Museum; Collaborator, Instituto de Ciencias Naturales (Bogotá).

quality but in the quantity of specimens which can be dried in a given period of time.

For collectors who are accustomed to gather many specimens of each number or many numbers, it is necessary to use artificial heat in order to dry rapidly, thus avoiding the accumulation of too much material which, in moist and hot climates especially, rots in a very short time. Some plant collectors, however, gather few specimens and few numbers since they are specializing in certain genera of plants; these investigators can easily take advantage of solar heat to dry their limited material without the danger of an over-accumulation.

During my four and one-half years of botanical activity in the Amazon drainage-area of Colombia, I have experienced considerable difficulty in the use of artificial and solar heat for drying specimens. Nearly all parts of the Colombian Amazonía are heavily forested, completely uninhabited or, at most, only very sparsely populated, lacking in communication facilities linking it with the centers of the nation, and without even the most indispensable equipment for work of this type. As it is my custom to spend long periods in botanical exploration away from centers, I have very frequently been beset by insurmountable difficulties in plant preparation. Neither the use of solar heat nor the employment of a gasoline stove has been satisfactory, although my collections are never extensive.

In the Amazon jungles, the procurement of gasoline for stoves is a constant and serious difficulty. When it is available, it is usually of an inferior quality that rusts and clogs the delicate mechanisms of pressure stoves. These mechanisms are often impossible to replace, and their repair in the field is usually out of the question. Nor can one utilize solar heat in most parts of the Amazon Valley because in these regions, especially during the "rainy season", the sky is often overcast for a number of consecutive days or even weeks, thus making it impossible to dry specimens in a press before their putrefaction and disintegration.

For these and other reasons (especially the great danger of fires, as well as the inevitable difficulty of having to travel great distances in open canoes with the voluminous equipment required by botanical work—tins, blotters, newspaper, tripods,

stoves, presses, gasoline drums, etc.—which always must be protected from storms and water), I decided to abandon drying in the field and use the method of preserving the undried specimens, pressed, in formaldehyde and sending them to Bogotá that they may be prepared conveniently and carefully there with an electric stove.

This method, which I have employed now for more than two years and which was suggested to me by Mr. Paul H. Allen, is little used amongst botanists and plant collectors because it is apparently not widely known. Various colleagues have shown such surprise in the success and the simplicity of this procedure that I have decided to publish the present article to recommend it highly, hoping that its advantages may also be of help to colleagues who are working in tropical climates.

The specimens are prepared as though they were to be dried at once in the field: i. e., between double news-sheets of ordinary size (12″ x 18″). The plant specimens are arranged, one to a sheet, and then pressed in the standard botanical press made of iron and chains or of wood and canvas straps. The plant material is left under heavy pressure for a day; when time permits, it is taken out to be rearranged before applying formaldehyde. An enamel metal tray of rectangular form about 10″ x 15″ and 3 or 4 inches deep is convenient. Into this tray, a quart of commercial 40% formaldehyde and one and one-half quarts of water are poured and mixed thoroughly. The open plant press is placed at the side of the tray, and the pressed specimens are dipped into the solution one by one. After a few moments in the solution, they are replaced, still dripping, between the news-sheets. The news-sheets with the specimens are placed one above the other and immediately put under pressure as previously applied. No blotters or cardboards are required unless an occasional specimen be extremely woody or pulpy. During the bath or before, the specimens may be numbered in the manner used by the collector. One must bear in mind, however, that the writing of some colored pencils is obliterated by formaldehyde; this can be avoided by using a heavy indelible pencil.

Once all of the specimens are well arranged and sufficiently pressed, they are enclosed in a rubberized bag or in any airtight container and are not removed again (except when one desires

to add more specimens prepared on successive days). Under these conditions, the plants will be conserved without damage for a month or more.

If shipment to a center must be delayed, it may be necessary to add a bit more formaldehyde to each specimen. This is done simply by bathing the specimens again or by spraying with a small amount of the formaldehyde-water mixture, then replacing the bundle in the rubberized bag. If transportation is not to take too much time, for example, about fifteen days, the concentration of formaldehyde can be weakened and up to two quarts of water or more per quart of formaldehyde can be added. If the plants are to be sent by mail, it is best to remove the pressed specimens from the press and tie them tightly in a bundle with twine. Then they should be wrapped in a double canvas to avoid as much as possible evaporation of formaldehyde during the trip.[3] The canvas should be strongly sewn, and the address may be printed on it with indelible pencil.

If the collection of a plant specimen be of any scientific value, then it follows naturally that the best attention and care should be given to its preparation.

At the present time, I am having excellent success in the use of the method described above. I am sending monthly collections of plants by mail from various parts of the Colombian Amazonía to the Instituto de Ciencias Naturales in Bogotá where they are dried with great care by well prepared technicians who have good stoves and excellent equipment as well as time at their disposal.

In the tropical jungle regions of Colombia, the very conservation of plant specimens already dried is a problem. Humidity, fungi, rats, ants, termites, worms, cockroaches and numerous other destructive agents, not to forget man and his usual carelessness, are constant and tireless enemies. For the difficulty of keeping dried specimens until shipment, if not for the other reasons mentioned above, I consider highly advisable the use of formaldehyde in plant collecting.

[3] Writer's note: Since publication of this article in Spanish, I have experimented with the use of the impermeable rubber-paper commercially known as "pliofilm" in wrapping bundles of formaldehyde-dipped specimens. The results have been highly successful. This pliofilm is a paper which does not crack and which can be sealed completely with a hot iron, providing an absolutely evaporation-proof container in which the effects of the formaldehyde will last many weeks longer.

In herbaria and in zoological museums, it is customary to preserve large and fleshy specimens of fruit and animals in bottles with solutions of formaldehyde. There is said to be one disadvantage in the continual conservation of vegetable material in formaldehyde, and that is the hardening of cellular tissues and the consequent difficulty in making microscopic or macroscopic dissection. However, I have been able to show by dissections of *Hevea* material that the use of formaldehyde in collecting as previously outlined does not harden the plant tissues unduly. It is also evident from the collections that specimens which have been under formaldehyde treatment in a plant press for as long as three months dry with artificial heat as well as or better than specimens which are dried immediately in the field. I have used formaldehyde with varying percentages of ethyl alcohol, but it appears that this is in no way advantageous and that formaldehyde alone, diluted in water as explained above, is sufficient. One quart of commercial 40% formaldehyde, diluted, is sufficient for preparing about 200 specimens. It has afforded me considerable satisfaction to see how successfully plants which are usually difficult to prepare and which often discourage the collector can be dried after treatment with formaldehyde. Fleshy plants such as many species of *Ficus* and *Clusia* as well as the pseudobulbs of many orchids flatten and soften under the influence of pressure and formaldehyde. Various species of *Melastomaceae* and *Loranthaceae*, usually brittle and fragile when dried, are conserved strong and resistant if first treated with formaldehyde. Flowers as delicate as those of *Clusia*, of various species of the *Lecythidaceae*, *Leguminosae* and *Bombacaceae*, and, curiously enough, the marvellous aquatic flower of *Victoria regia* are prepared very neatly with this procedure. Numerous *Leguminosae* with finely pinnate leaves, whose leaflets almost always fall during drying, are preserved intact. We might also include many *Bignoniaceae* and *Convolvulaceae*, some *Solanaceae* as well as *Cucurbitaceae* and *Passifloraceae* and others with membranaceous or ephemerous flowers.

Lactiferous trees, such as species of *Hevea, Castilla, Sapium, Couma* and *Hancornia*, usually lose their leaves very rapidly due to fermentation of the latex and formation of an abscission layer. I have used the formaldehyde procedure with excellent

success in the preparation of hundreds of specimens of *Hevea*, in which the flower as well as the fruit is very susceptible to rapid putrefaction and in which the trifoliolate leaves very often disintegrate, even when subjected to immediate artificial heat shortly after collection.

One disadvantage in using formaldehyde is the damage it causes to the skin. Since it is a dehydrating agent, it cracks and blackens the hands after several days' contact and an acute pain is produced. This may be avoided by the use of rubber surgeons' gloves or by smearing the hands with vaseline or cold cream before bathing the specimens. Pincers may also be used to handle the plants. However, when one is collecting and preparing plants continuously and over long periods, my experience indicates that these precautions are very much more troublesome than the physical inconvenience caused by the chemical.

The formaldehyde method should be convenient not only for professional collectors who are working at great distances from their bases, but it should also prove of use to students who often make botanical excursions of a few days' duration, who have no time to prepare and dry their material during the trip, and who find it difficult to carry bulky botanical equipment. If one uses formaldehyde, one needs carry only a plant press, newspaper, a tray and a bottle of formaldehyde. This equipment is so light and easy to carry that it can be taken even by aeroplane. On occasional trips, the purpose of which is not strictly botanical, the formaldehyde "kit" would be useful because one might unexpectedly arrive at some remote locality where it would be possible to find plants of importance to phytogeographical investigations.

In the case of extensive collections, it might seem that the cost of formaldehyde would be excessive due the exorbitant cost of this chemical at the present time in Colombia. In reality, however, if one considers the conveniences it affords, the formaldehyde procedure is not costly even under present conditions. Where there are no facilities to use other methods of collecting and drying, it must be considered false economy to forego the use of formaldehyde for fear of its initial cost. It should be considered an insurance policy for work which requires so much

interest and sacrifice on the part of the naturalist-collector. Furthermore, although all of us ought to work as economically as possible, the time has come to insist that botanists do not have to carry out their expeditions and explorations in the traditional manner with microscopic budgets compelling them to travel about almost like beggars asking alms.

The best materials and the most modern methods ought to be available to the botanist (as in the case of most other scientists), for he is dedicated to one of the oldest, most profound and most fascinating of the sciences and one which is, at the same time, of fundamental economic importance for the progress of mankind.

Bogotá, Colombia

A New Station for Epipactis Helleborine in New Hampshire.—In view of the scarcity of stations in New Hampshire for *Epipactis Helleborine* (L.) Crantz, I am recording a station on the northeastern section of Bear Island in Lake Winnepesaukee in Meredith. The colony is small, about twenty plants, and the possibility of introduction from any near-by cultivated gardens is remote. The plants grow on a hillside of mixed trees in moist soil and there is evidence of a temporary brook in the spring. I found no plant over a foot high and most of them were smaller. One specimen has been sent to the Gray Herbarium, another to the Philadelphia Academy of Natural Sciences; and seeds have been retained for a trial on artificial culture media. The previous record for New Hampshire is of a small colony at Plainfield, somewhat farther west, noted by Alan W. Upham in Rhodora, xliv. 456 (1942).—Robert J. Titherington, Philadelphia 38.

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